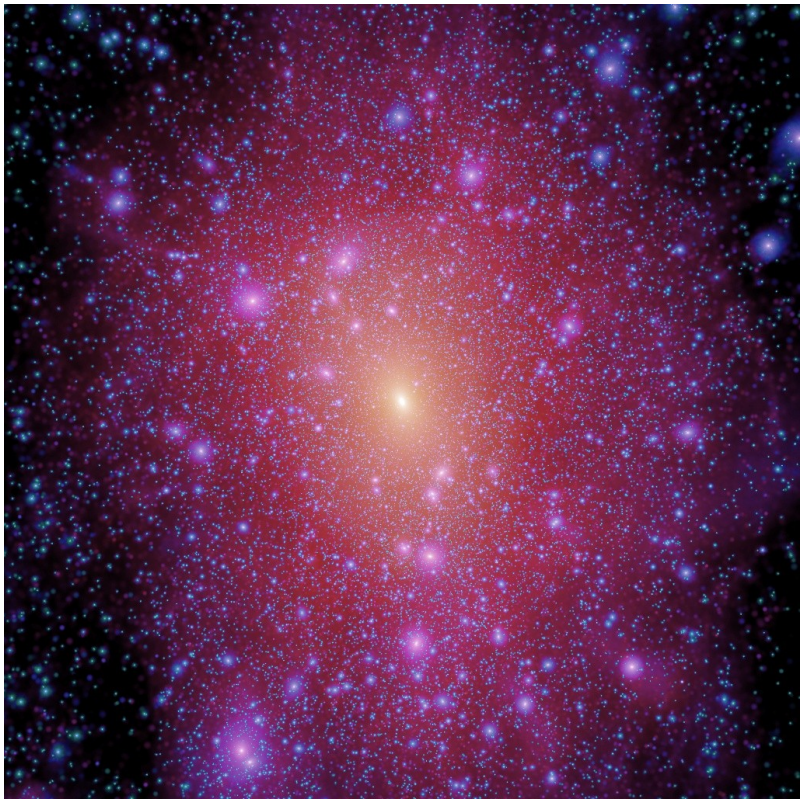
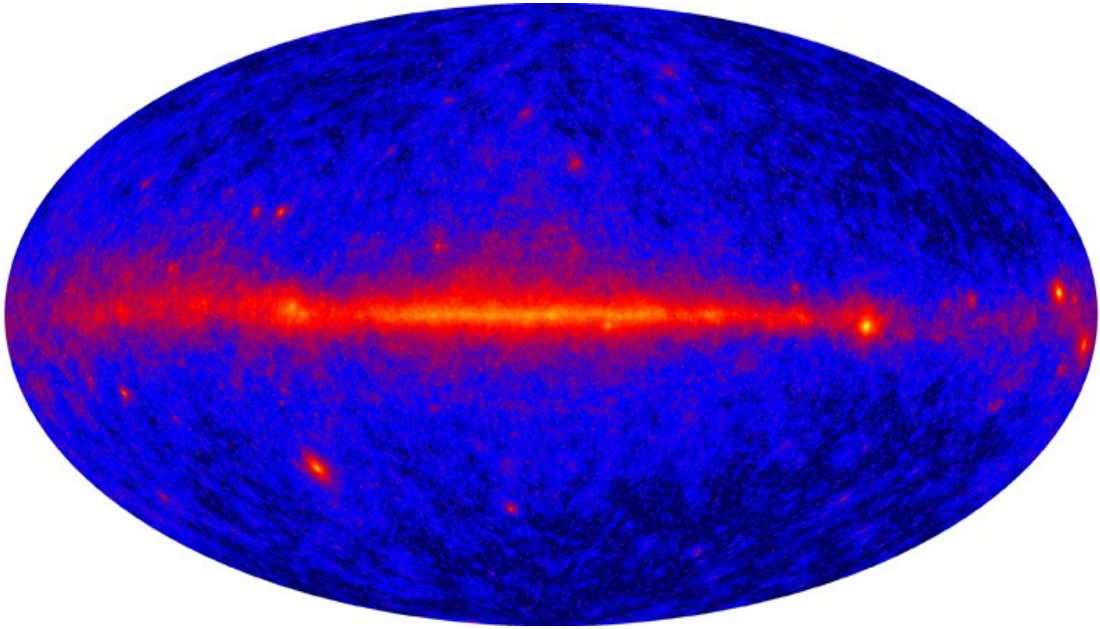
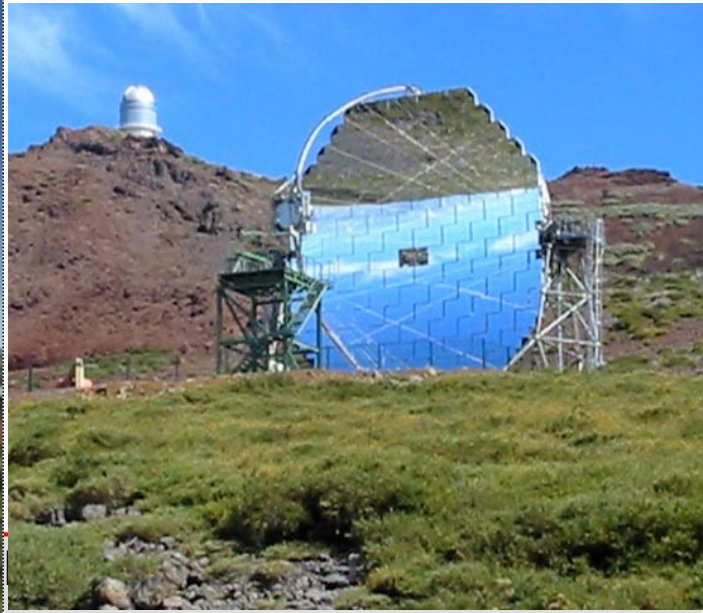
Indirect Dark Matter searches with Cherenkov telescopes: status

- Dieter Horns (University of Hamburg)

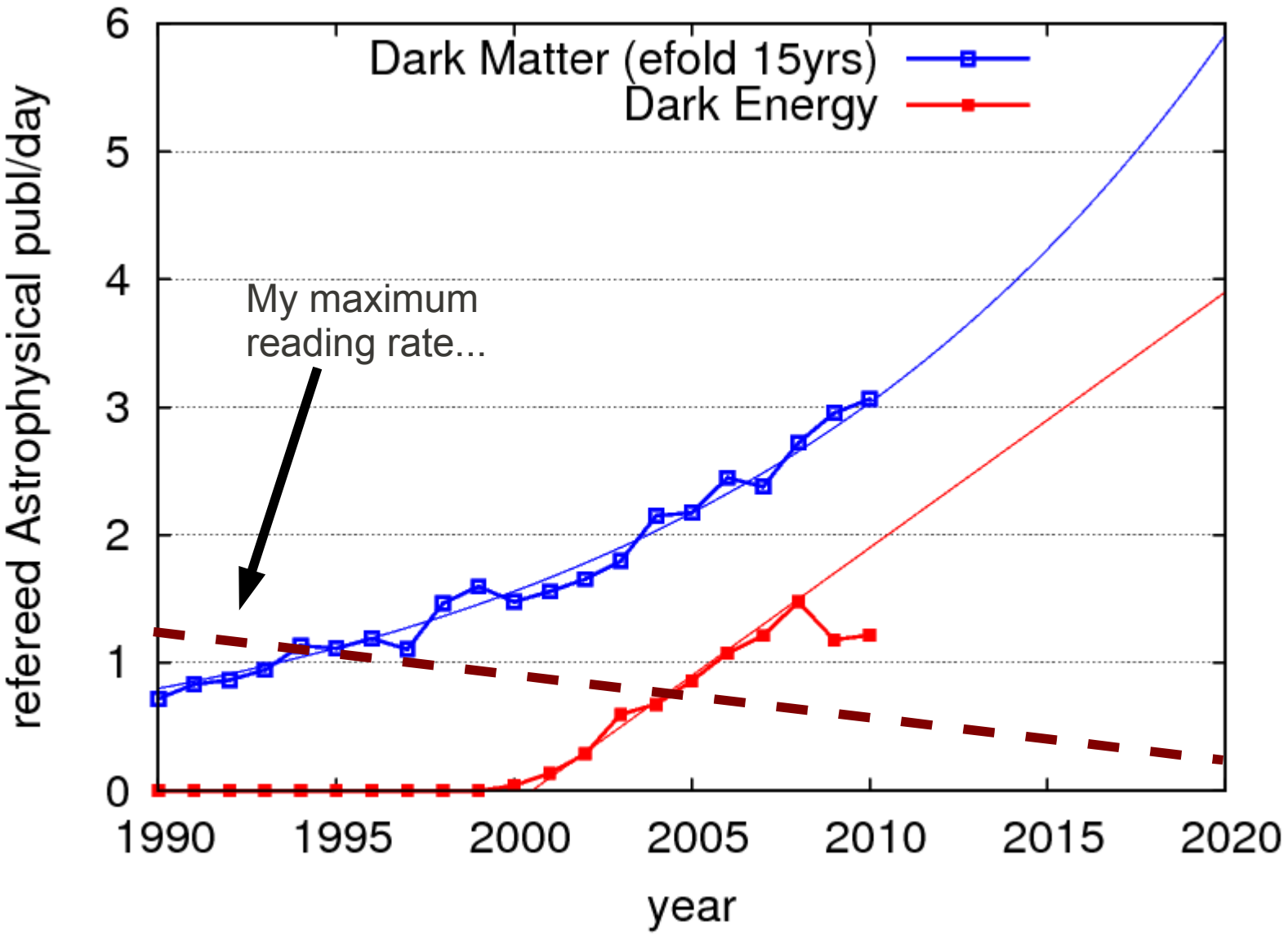
Overview







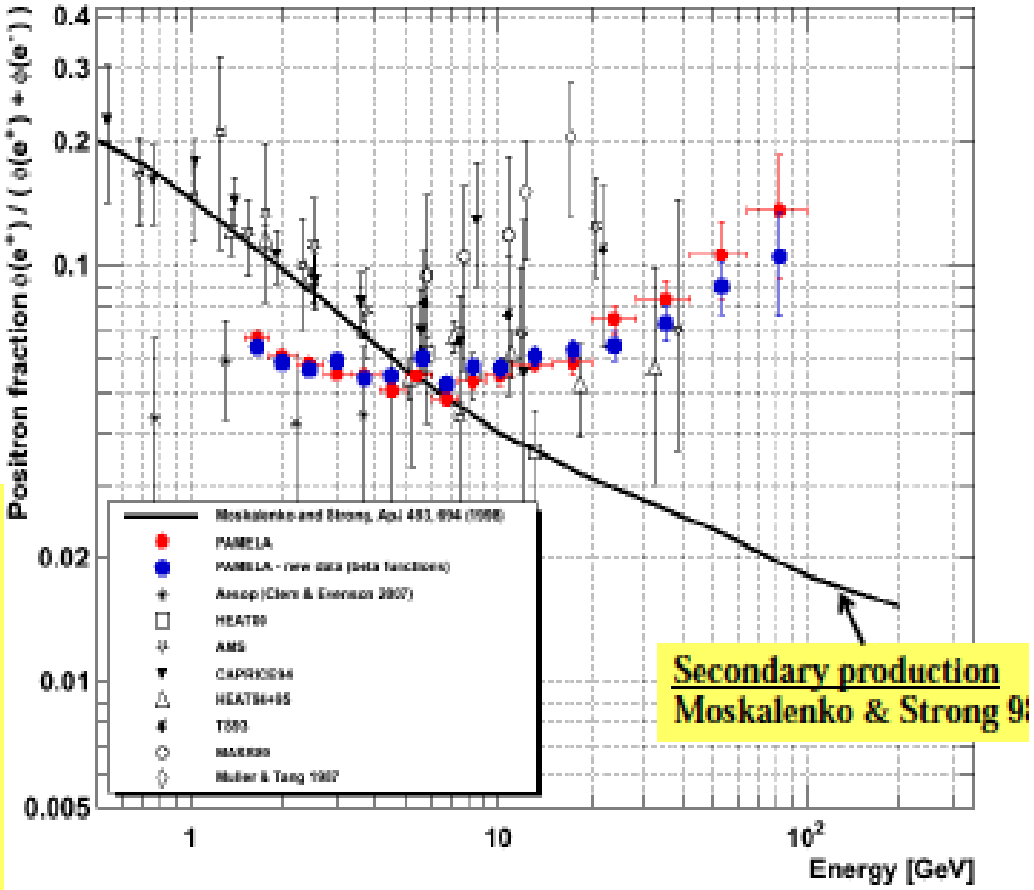
Busy times for Dark research

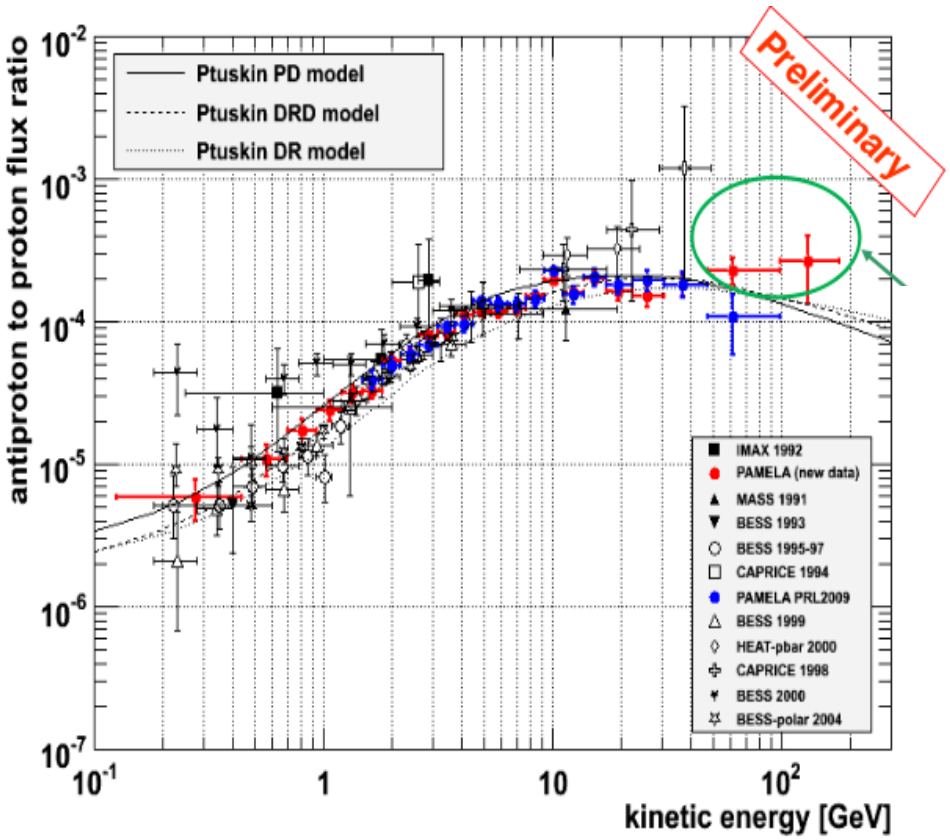


Based upon SAO/NASA ADS-Service

PAMELA anomaly

[Adriani et al. 2009]





Anti-matter (e^*) from self-annihilating DM?

No excess of anti-protons!

Secondary Positrons

The problem with the rising e^+ fraction

$n_{CR} \sim E^{-\Gamma-\delta}$ (Escape/diffusion)

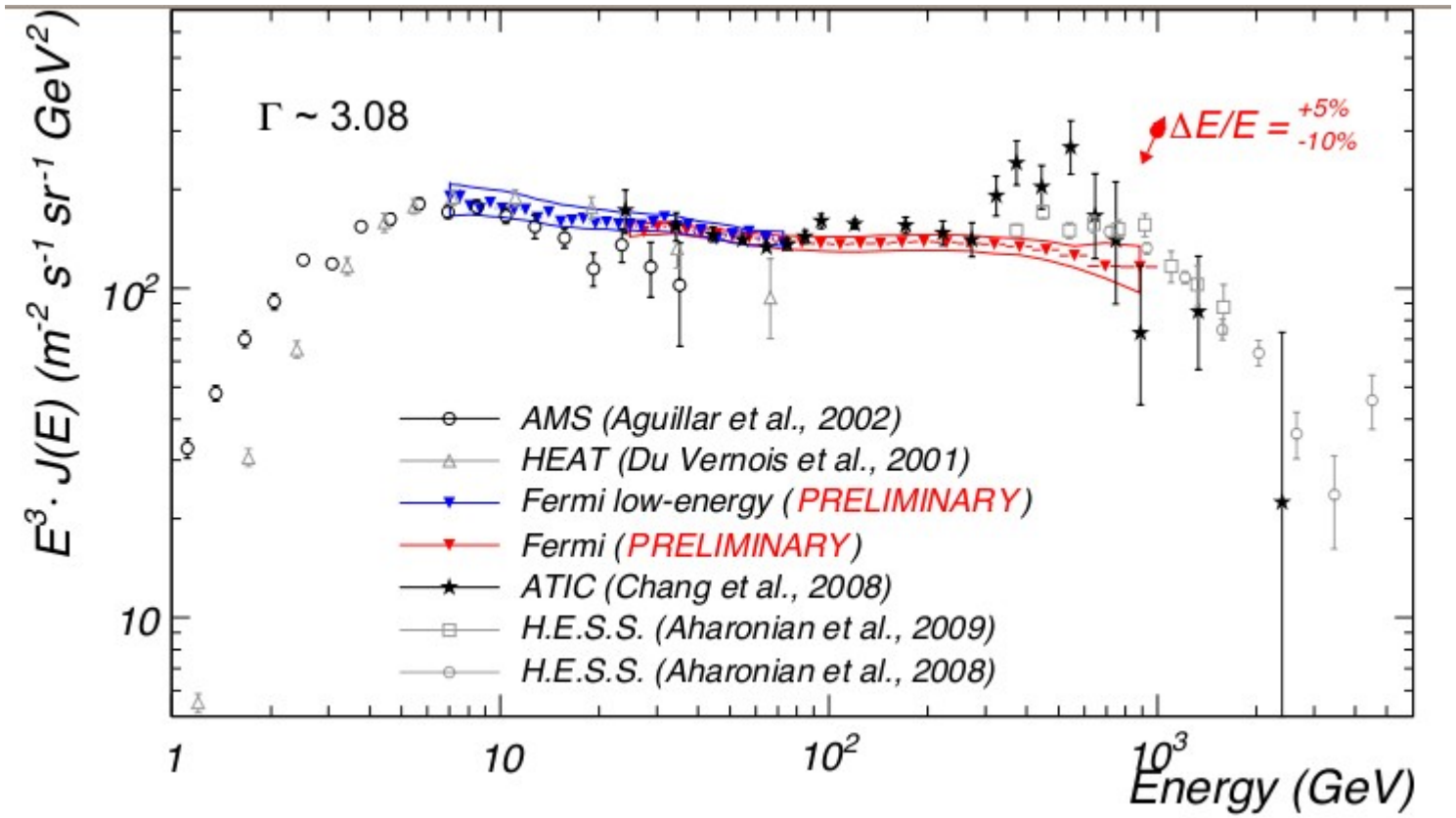
$n_- \sim E^{-\gamma-1}$ (Cooling)

$q_+ = n_{cr}/t_{pp->e+} \sim E^{-\Gamma-\delta}$

$n_+ = q_+ t_{cool} \sim E^{-\Gamma-\delta-1}$

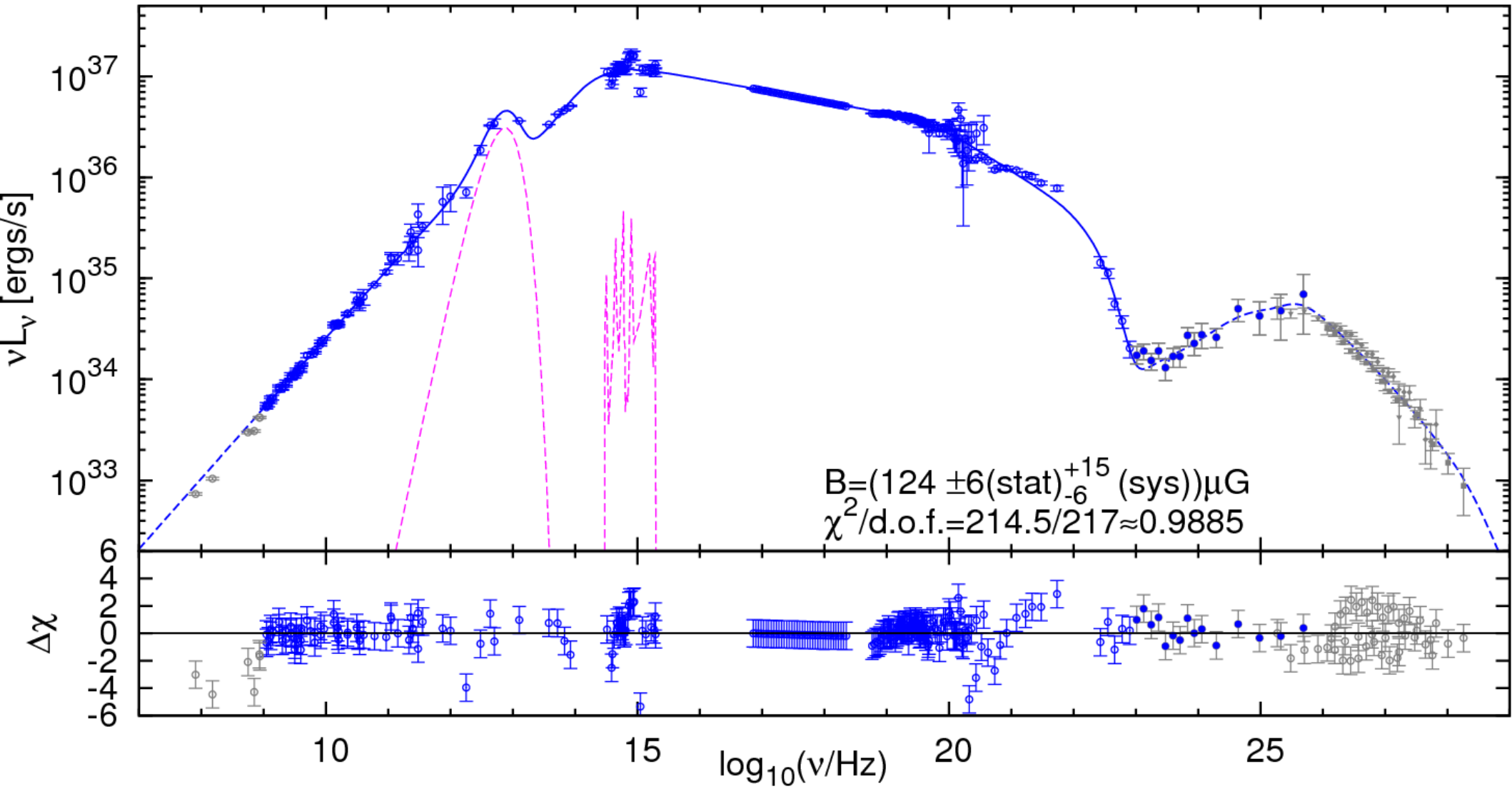
$$n_+/n_- \sim E^{-\Gamma-\delta+\gamma}$$

- Hard electron spectrum + cut-off!



Cross calibration of Fermi/IACTs

[Meyer, DH, Zechlin 2010]



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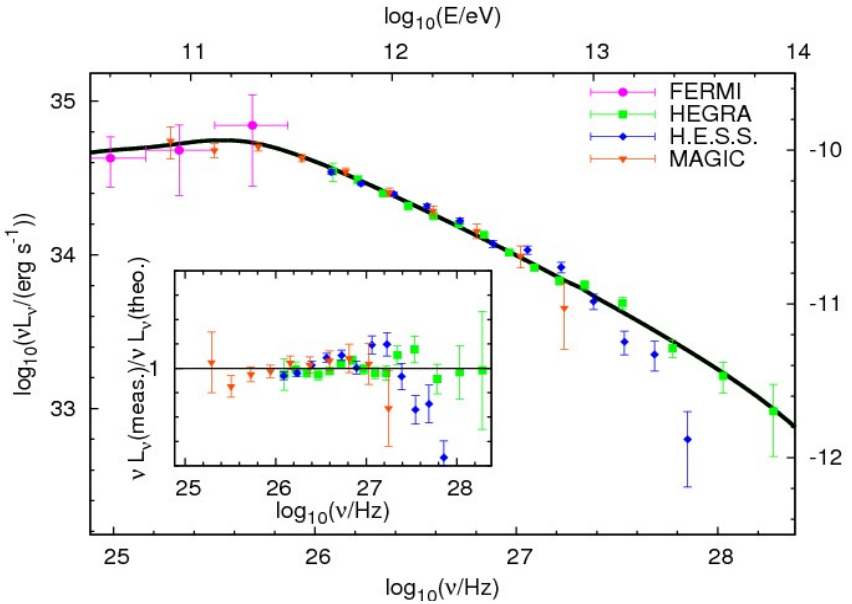
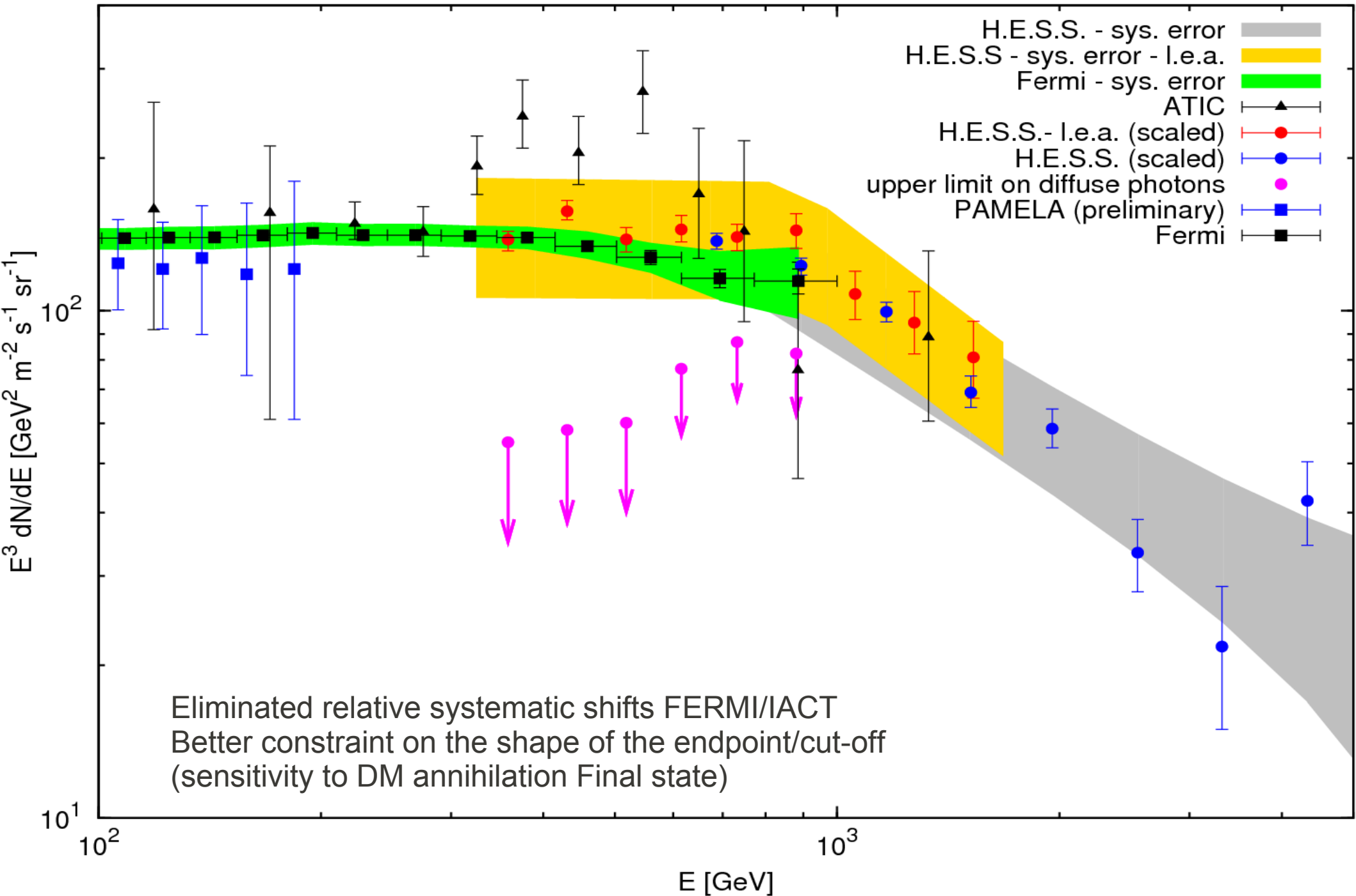


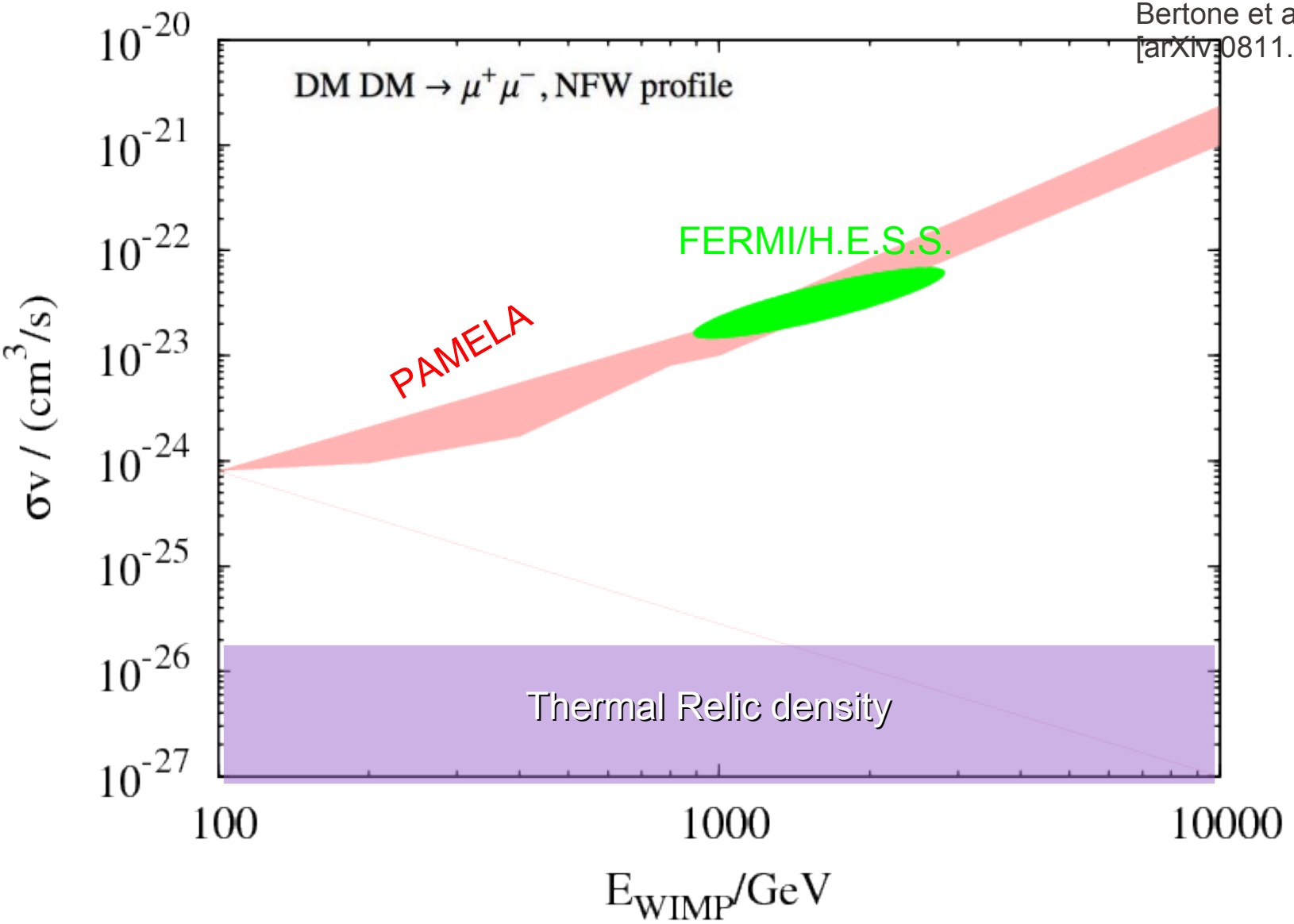
Instrument	Scaling factor s_{IACT}	Stat. error Δs	χ^2_{before}/d.o.f.	χ^2_{after}/d.o.f.
Fermi/LAT	1	+0.05 −0.03	–	0.49
HEGRA	1.042	±0.005	7.652	1.046
H.E.S.S.	0.961	±0.004	11.84	6.476
MAGIC	1.03	±0.01	1.671	0.656

Scaled electron spectrum



Preferred model

Adapted from Meade et al. 2009 [arXiv 0905.0480], Bertone et al. [arXiv:0811.3744]



Large production rate
(boost factor ~10^3)
and
High (~TeV) masses :

Ideal parameters
for ground based
Air Cherenkov detectors!

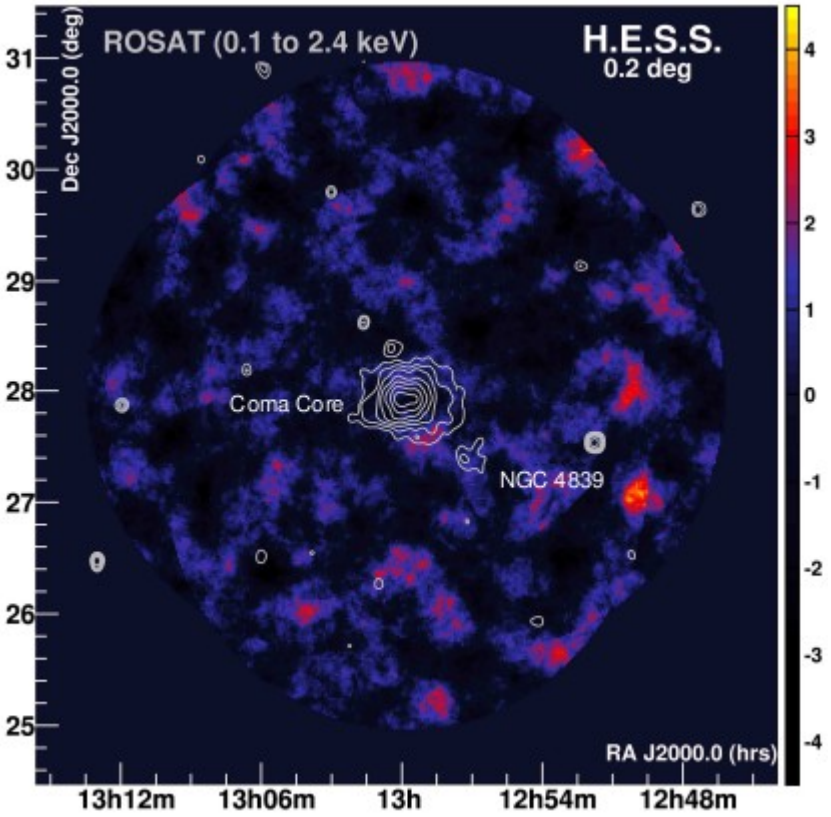
However: we haven't found anything yet

Observations

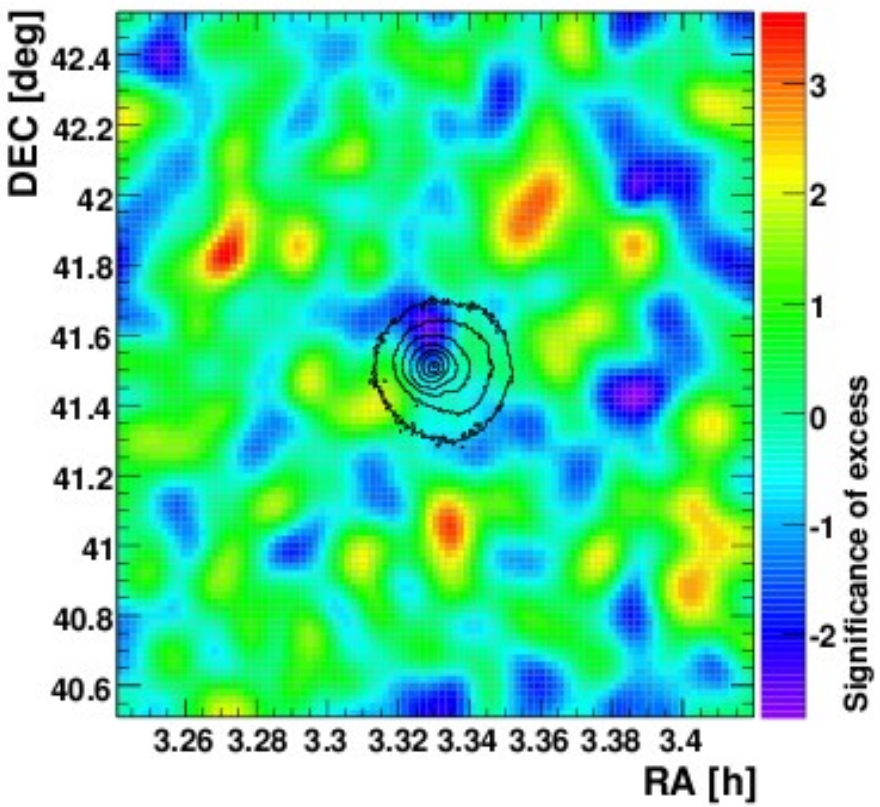
- Dark matter dominated objects at different mass scales (10^6 M_{sun}...10^{15} M_{sun})
  - Dwarf spheroidal galaxies (>99% dark matter)
    - small cosmic ray contamination
    - Disturbed halos, substructure?
  - Galaxy clusters (confusion with Cosmic Ray produced gamma-rays!)
    - Relaxed dark matter halo
    - Substructures should be present
    - cosmic ray contamination

Lots of empty skymaps..

Coma cluster



Perseus cluster



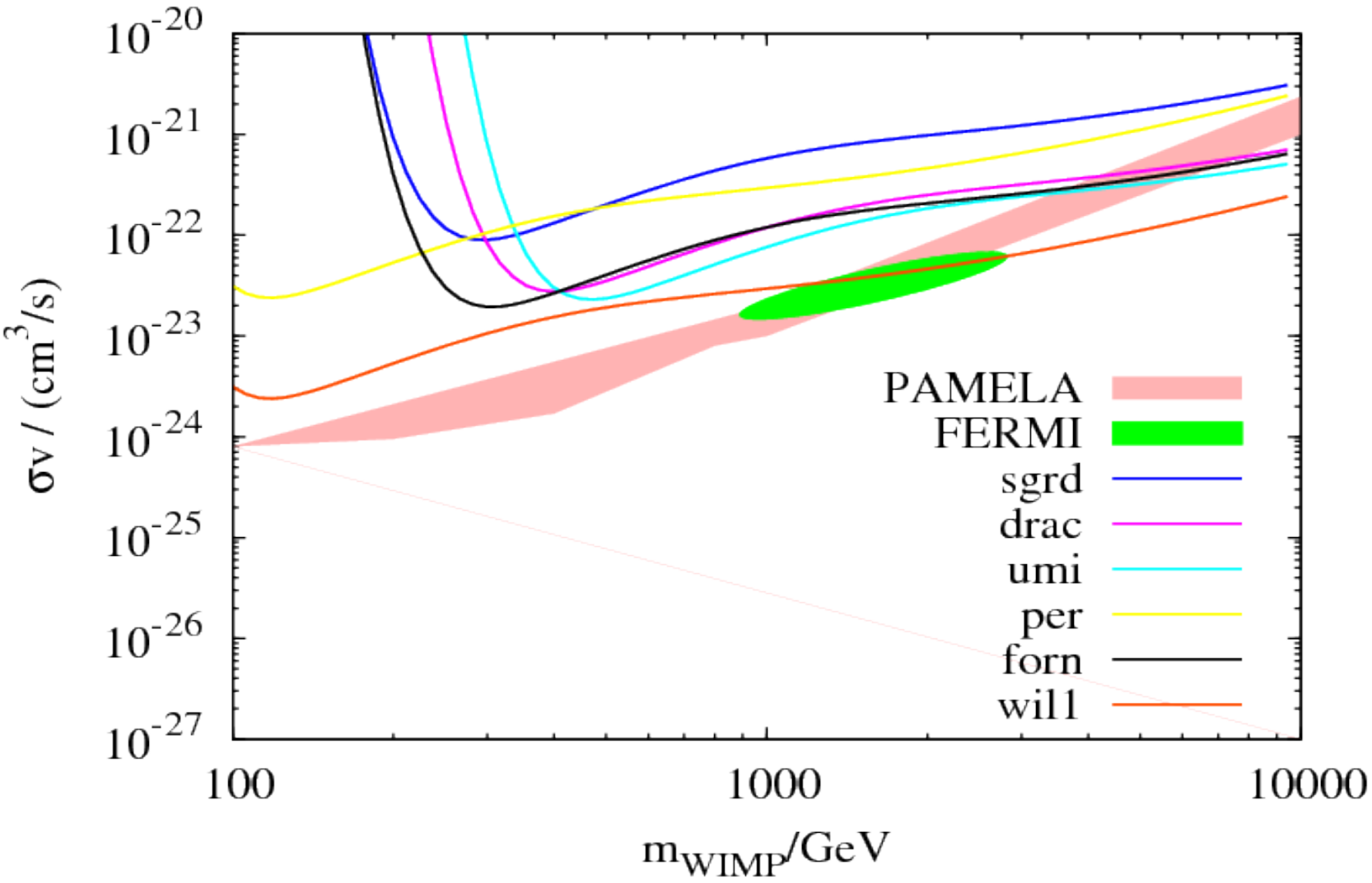
Analyse all upper limits in a consistent way using
Astrophysical factors with $c \sim M^{-0.1}$ (Bullock et al. 2001)

List of objects and observations

Object	Observation	Threshold	Limit	J 1e-23 GeV^2/cm^5	Reference
Sgr Dwarf	11hrs H.E.S.S.	250 GeV	3.6e-12	1	arxiv:0711.2369
Draco	7.8 hrs MAGIC	140 GeV	1.1e-11	0.6	arxiv:0711.2574
Draco	7.4 hrs Whipple	400 GeV	6.8e-12	0.6	arxiv:0801:1708
Draco	18.4hrsVERITAS	340 GeV	5e-13	0.6	arxiv:1006.5955
Ursa Minor	7.9 hrs Whipple	400 GeV	9.2e-12	0.8	arxiv:0801:1708
Ursa Minor	18.9hrsVERITAS	380 GeV	4e-13	0.8	arxiv:1006.5955
Canis Major	9.6 hrs H.E.S.S.				arxiv:0809.3894
Willman 1	15.5 hrs MAGIC	100 GeV	1e-12	1.2	arxiv:0810.3561
Willman 1	13.7hrsVERITAS	320 GeV	1e-12	1.2	arxiv:1006.5955
Boötes 1	14.3hrsVERITAS	300 GeV	2.2e-12	0.5	arxiv:1006.5955
Perseus	24.4 hrs MAGIC	100 GeV	5e-12	0.6	arxiv:0909.3267
Coma	8 hrs H.E.S.S.	1000 GeV	6e-13	0.5	arxiv:0907.0727
Fornax	18 hrs HESS	260 GeV	1e-12	1	arxiv:0709.2778

Unified analyses

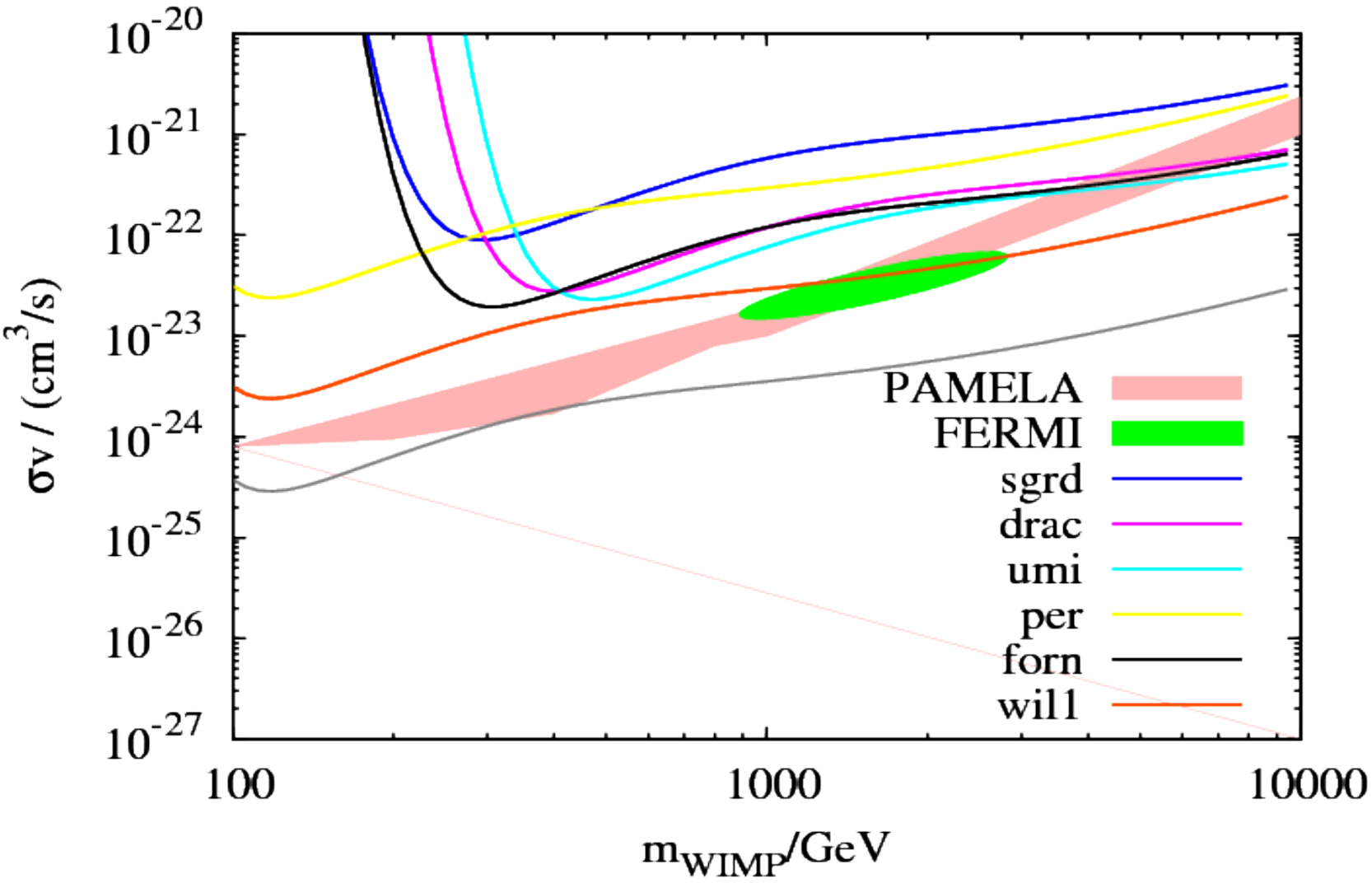
- Under the assumption of a W^+W^- annihilation spectrum:



- Assumption for a nearby clump:
  - $dn/dm \sim m^{-1.9}$
  - $N(>10^8\ M_{sun})=100$
  - Expect 1 clump with $M\sim10^4\ M_{sun}$ within ~1 kpc
  - $c\sim M^{-0.1} \rightarrow$ extension of approx 0.2° at 1 kpc
- Assumed sensitivity above 100 GeV Flux=10^{-12} $cm^{-2}\ s^{-1}$
- More refined model (tidal truncation) required

Nearby clump (1 kpc)

- Under the assumption of a W^+W^- annihilation spectrum:



Outlook

- Observations of 6 dwSph + 3 prominent galaxy clusters → No detection
- More (deeper) observations (of further objects) are carried out → more to come
- Sensitivity ~sufficient to detect Pamela/Fermi DM
- Improved accuracy on the electron spectrum (cross-calibration) requires more statistics (easy), reduced systematics (tough)